TOWARDS A THEORY OF MODELING GRAMMAR ACCEPTANCE

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Abstract

Studying the acceptance of Information Systems (IS) artifacts is classic to the IS research discipline, as is the study of conceptual modeling and associated phenomena. However, research has not yet sufficiently combined these two lines of inquiry to explore user acceptance of conceptual modeling. The paucity of such research has motivated our study on the acceptance of modeling grammars. In this paper, fundamental research models on IS acceptance and conceptual modeling are synthesized in the development of a theoretical model designed to measure the relevance of representational capabilities of modeling grammars to the explanation and prediction of the intention by modeling individuals to continue to use them. The model-building process is discussed, as is the identification of sub-constructs for derivation of appropriate measurements for the empirical testing of the model. We conclude with an outlook of how the developed model will be deployed in an empirical test that seeks to validate the theorized constructs and relationships.

Keywords: Technology Acceptance Model, Bunge-Wand-Weber model, conceptual modeling

Introduction

Studies on the success of Information Systems (IS) artifacts are one of the core research directions in IS. Success as a consequential variable of interest embraces different dimensions, notions and measures. In fact, there are nearly as many measures for success as there are studies [DeLone and McLean, 1992]. Reported measures include the notions of accuracy [Shannon, 2001], influence [Mason, 1978], or impact and user satisfaction [Grover *et al.*, 1996]. Aside from these notions, one of the most frequently reported measures for success is usage [DeLone and McLean, 1992, 2003]. The importance of the usage measure in the context of IS success stems from the fact that only when an information systems artefact is utilized by its intended users it releases its potential to generate benefits, influence or impact [Agarwal and Karahanna, 2000]. However, as DeLone and Mclean [2003] note, deeper insights are needed into what exactly determines usage, and ultimately success, of an artifact. In this context it is often noted that it is foremost the question of the *acceptance*, and not so much potential superior capabilities, of an IS artifact that determines the realization of its benefits [Davis, 1989]. Potential performance gains that may stem from the prolonged use of an IS artifact are often obstructed by users' unwillingness to accept and use the available artifact [Bowen, 1989, Young, 1984]. Because of the persistence and importance of this phenomenon, user acceptance has traditionally been a key issue (and key measure) in IS success research [Ginzberg, 1981, Lucas Jr., 1975, Robey, 1979, Swanson, 1974, Swanson, 1987].

This insight holds true even more so in the area of conceptual modeling. This IS domain is coined by the proliferation of a wide range of rather arbitrary approaches and a large selection of available conceptual modeling grammars [Olle *et al.*, 1986]. Some of these grammars have been shown to differ quite significantly in their representation capabilities,

for example [Opdahl and Henderson-Sellers, 2002, Rosemann *et al.*, 2006b, Wand and Weber, 1993], and their correctness and ease of use [Batra *et al.*, 1990, Yadav *et al.*, 1988]. Other research has also shown that substantial differences exist between different conceptual modeling grammars with respect to their ability to support domain comprehension and task solving, for example, [Agarwal *et al.*, 1996, Brosey and Shneiderman, 1978]. Seemingly independent from the differences in their capabilities, may they be superior or inferior, certain conceptual modeling grammars have achieved high levels of adoption and dissemination in modeling practice (Entity-Relationship Diagrams [Chen, 1976], UML [Fowler, 2004] or BPMN [BPMI.org and OMG, 2006], for example), while others still remain as an object predominantly of interest to academic scholars, for instance, Petri Nets [Petri, 1962] and its variants [van der Aalst, 1998].

Accordingly, in this research we are concerned with *grammars used for conceptual modeling*, which are reportedly of high relevance to the IS discipline in general [Weber, 1997] and to IS development processes in particular [Karimi, 1988]. We see a reason for our study in the fact that while in general conceptual modeling is a well-researched subject in the IS field [Wand and Weber, 2002], there is a paucity of empirical and usability studies of phenomena associated with conceptual modeling [Moody, 2005]. In fact, very little is known about the adoption and user acceptance of conceptual modeling grammars and methods overall [Wynekoop and Russo, 1997].

Of all models that have been proposed to explain the acceptance of IS artifacts, for example, [Bhattacherjee, 2001, Rogers, 2003, Venkatesh *et al.*, 2003], the Technology Acceptance Model (TAM) [Davis, 1986, 1989, Davis *et al.*, 1989] has been most influential. In fact, a recent meta analysis [King and He, 2006] has shown that TAM in its original form is most robust and reliable. Many TAM studies have been published over the years, leading to the statement that TAM denotes one of the few theories unique to the IS discipline that have not

only obtained wide-spread acceptance in the field but also considerably high levels of maturity and rigor [King and He, 2006, Lee *et al.*, 2003]. As such, we see potential and first evidence that TAM could successfully be applied to the study of the acceptance of conceptual modeling grammars, an area to which it has so far not at all been applied. However, in contrast to the proven relevance of the general model of technology acceptance, there remains a need for studies further exploring the antecedents and determinants of TAM's primary constructs, not in general but in correspondence to the particular research context [King and He, 2006, Lee *et al.*, 2003]. Legris *et al.* [2003] found in their meta-analysis of TAM that external variables determining TAM's primary constructs have received relative little attention. This, in our research context, raises the question of the external precursors (prior factors) that lead to the primary constructs explaining the intention of continuance (as a surrogate for acceptance) of a conceptual modelling grammar. Consequently, we observe a need to further explore those determinants of the acceptance of modeling grammars that are specific to the conceptual modeling context. In line with Downs and Mohr [1976] who distinguish primary characteristics (those that are intrinsic to an artifact) from secondary characteristics (those that may vary in dependence to the situational context in which the artifact is embedded and/or studied), and in line with Moore and Benbasat [1991] who state that a sole focus on primary attributes may lead to inconsistent results (because it is the way that artifact users *perceive* its characteristics that determines their behavior), we propose to study the perceived characteristics inherent to modeling grammars and their effect on grammar acceptance.

An appropriate research method that provides insights into the characteristics and capabilities of modeling grammars, is by principle of *representational analysis* by means of models of representation, such as the Bunge-Wand-Weber representation model [Wand and Weber, 1993, Wand and Weber, 1995]. Similar to TAM, which has reportedly been used in over 85

IS studies [Lee *et al.*, 2003], Wand and Weber's theory of representation has an extensive track record in IS with more than 30 reported studies [Green and Rosemann, 2004]. However, most of these studies are limited to identifying theoretical, and sometimes empirically validated, representational shortcomings of grammars, and do not connect these findings to further dependent variables such as the quality or success of modeling practice overall, or the acceptance of modeling grammars by modeling individuals (henceforth also called users) [Recker *et al.*, 2006b, Wand and Weber, 2002].

Accordingly, in this paper we seek to merge the two mentioned prominent theories in order to develop a theory of understanding of the factors accounting for user acceptance of conceptual modeling grammars. In particular, we will extend TAM with principles from representational analysis in order to understand and predict how *perceived modeling grammar capabilities* affect the formation of *the intention to continue to use* a certain grammar for modeling tasks. A combination of both theories will strengthen our research in terms of rigor and explanatory power, but more broadly we see an opportunity to bring together two IS 'camps', and to amalgamate two of the most influential approaches to IS research overall. Corresponding to comments about the extent of diversity in theories employed in IS research [Benbasat and Zmud, 2003, Robey, 1996, Vessey *et al.*, 2002], several authors have expressed concerns about the ongoing quest for a *cumulative tradition*, in the hope of evolving to a self-aware research discipline that builds on the existing body of knowledge, has an awareness for the remaining open challenges, and is guided by a methodological procedure in its future research efforts [Keen, 1980, Kuhn, 1962, Weber, 1997]. We consider our move a significant step towards the evolvement of a discipline that builds on the existing body of knowledge and has awareness for the remaining open challenges. In particular, we see an opportunity to countervail ongoing IS research trends towards divergence rather than convergence in research being conducted [Teng and Galletta, 1990] by testing *the combination of theories*

that are unique to the Information Systems research discipline. Thereby, the scope and boundaries of the theories can be expanded and extended, which in turn allows the discipline to advance the state of research by means of creative and novel theory adaptations and applications that have not yet been envisaged.

Accordingly, the *aim of this paper* is to develop a theoretical model, based on TAM and extended with principles from representation theory, to explain the users' intention to continue to use a conceptual modeling grammar. We proceed as follows. The next section gives the background to our model by recapitulating relevant theories in the field of conceptual modeling grammars and IS acceptance. We then report on our model of grammar acceptance that we derive from these theories and discuss its primary, secondary and moderating constructs. We conclude our paper by discussing our contributions and providing an outlook to future research opportunities, especially how the model will deployed in a subsequent empirical study that tests the theorized constructs and relationships.

Background & Related Work

Conceptual Modeling

The task of conceptual modeling is widely acknowledged as inevitable for IS engineering [Karimi, 1988] and can be described as building a (predominantly graphical) representation of selected phenomena in a domain of interest [Mylopoulos, 1992, Siau, 2004, Wand and Weber, 2002]. Conceptual modeling takes place foremost in requirements engineering phases of IS development processes and determines the acceptability and usability of the artifact to be built [Lauesen and Vinter, 2001].

We focus on conceptual modeling grammars in our study, following the definition of Wand and Weber [2002] that a *grammar* is a set of (graphical) constructs, and rules showing how to

combine the constructs, for modeling real-world domains. More specifically, we use the example of the recently proposed Business Process Modeling Notation (BPMN) [BPMI.org and OMG, 2006] as an instance of a conceptual modeling grammar. Our selection can be justified on several counts. First, process modeling has been identified as one of the most popular reasons for conducting conceptual modeling [Davies *et al.*, 2006]. Second, Bandara *et al*. [2005] have identified the process modeling language (i.e., grammar) as a distinct factor relevant to the overall success of process modeling initiatives. Hence, we see an opportunity to further explore the antecedents of the impact that grammars have on process modeling success. Third, recent moves in process management practice have shown a trend towards industry standards [Davenport, 2005]. BPMN denotes the latest, and most popular, candidate of a grammar proposed as a modeling industry standard. It was officially released in 2004, and since then, a strong boost of popularity around BPMN could be witnessed (see www.bpmn.org). For instance, recent studies on BPMN usage [Recker *et al.*, 2006a] show that, at least in Australia, a significant number of organizations have already adopted BPMN. Given the attention that BPMN has been receiving we see a need for exploring the main drivers and barriers of the intention to start, and to continue, using process modeling grammars in general and BPMN in particular.

Conceptual modelling as such is a well-researched subject in IS [Wand and Weber, 2002]. However, the majority of past studies has focused on the development of new approaches to conceptual modelling [Galliers and Swan, 2000, Punter and Lemmen, 1996] rather than on the critical evaluation and improvement of existing approaches [Moody, 2005]. The multiplicity of available modelling approaches has often cynically been reflected, for instance in the acronym YAMA (Yet Another Modelling Approach) [Oei *et al.*, 1992], which ironically has also been used to name new modelling grammars such as YAWL (Yet Another Workflow Language) [van der Aalst and ter Hofstede, 2005] or yEPC (Yet Another Event-

driven Process Chain) [Mendling *et al.*, 2005]. However, the traditional focus in conceptual modelling research on artefact development induces a need for evaluative studies. Several researchers state that there is a need to shift academic resources from development to evaluation and to strive for progress in the field of theoretical foundations and quality frameworks for conceptual modelling [Galliers and Swan, 2000, Moody, 2005, Oei *et al.*, 1992, Punter and Lemmen, 1996, Wand and Weber, 2002]. Progress towards quality measures of conceptual modelling obviously is relevant not only to academics but also to practitioners [Olle *et al.*, 1991]. Yet, the amount of research dealing with evaluation of conceptual modelling quality is considerably low. Research on the quality of phenomena associated with conceptual modelling within the Information Systems discipline is found to be still in the premature stages [Moody, 2005, Nelson *et al.*, 2005]. Aside from the lack of evaluation research in the field of conceptual modelling, the low extent of empirical research in this area is worrisome. Even if empirical testing is one of the cornerstones of scientific endeavours [Neuman, 2002], empirical studies on conceptual modelling are scarce at best (reportedly under twenty percent) [Moody, 2005], which in turn prevents the research discipline from advancing to a more mature and established status [Poels *et al.*, 2003]. The list of empirical studies on phenomena associated with conceptual modelling includes, *inter alia*, success factor models [Bandara *et al.*, 2005, Bandara and Rosemann, 2005], usability studies [Hitchman, 1995, Poels *et al.*, 2005], studies on data model quality [Moody and Shanks, 2003] or model verification [Bernárdez *et al.*, 2004]. A wider overview is given in [Moody, 2005]. However, there is a noted lack of studies that investigate the practical adoption and dissemination of conceptual modelling in industry practice, be it developed artefacts such as methods, tools or grammars [Wynekoop and Russo, 1997] or the results of quality-related research [Kaindl *et al.*, 2002, Moody, 2003b]. A notable exception is the study by Tan and Siau [2006] who report on the influence of external factors such as market

penetration and standardization on the acceptance of conceptual modelling methods by IS developers. With their focus being on external drivers of acceptance, we are motivated to study internal drivers, i.e., grammar capabilities, and the extent to which they account for the intention to continue to use the grammar.

Regarding IS theories related to conceptual modeling grammars that may form a suitable starting point for our investigation, recent years have seen the emergence of a promising candidate, *representation theory* based on models of representation, for a theoretical foundation of conceptual modeling. The BWW model has an extensive track record in the Information Systems discipline, documented by well over one hundred publications drawing on this model in contexts such as comparison of modelling grammars [Rosemann *et al.*, 2006b], modelling grammar foundations [Wand *et al.*, 1995], model quality measurement [Gemino and Wand, 2005] or modelling method engineering [Wand, 1996]. Aside from its demonstrated usefulness in studies of phenomena associated with conceptual modelling the BWW representation model has also been used in related research domains, for instance in studies on Information Systems requirements engineering [Soffer *et al.*, 2001]. Most notably, however, the BWW model is used the context of *representational analysis* of capabilities and shortcomings of conceptual modelling grammars, with a track record of more than thirty reported studies [Green and Rosemann, 2004]. A review of these studies is omitted in this reported and instead the interested reader is referred to the annotated overviews given, for instance, in [Green and Rosemann, 2004, Green *et al.*, 2005].

Weber [1997] suggests that representational analysis can be used to make predictions about the capabilities of a grammar to provide *complete* and *clear* representations of a real-world domain, by comparing the constructs of the BWW representation model (for example, thing, transformation) with the constructs of the modeling grammar (for example, event, activity). The basic assumption is that any deviation from a 1-1 mapping relationship between

grammar constructs and BWW constructs induces a situation of representational deficiency in the grammar. Two principal evaluation criteria may be studied: *ontological completeness*, i.e., the analysis of the extent to which a modeling grammar has a *deficit* of constructs mapping to the set of constructs proposed in the BWW representation model, and *ontological clarity*, i.e., the analysis of the extent to which modeling grammar constructs are deemed *overloaded*, *viz*., they map to two or more constructs in the BWW model, *redundant*, *viz*., two or more grammar constructs map to the same construct in the BWW model, or *excess*, *viz*., they map to none of the constructs in the BWW model (see Figure 1). This mode of analysis rests on the assumption that, essentially, Information Systems are representations of real-world systems and consequently models of information systems need to contain the necessary representations of relevant real-world phenomena [Wand and Weber, 1995].

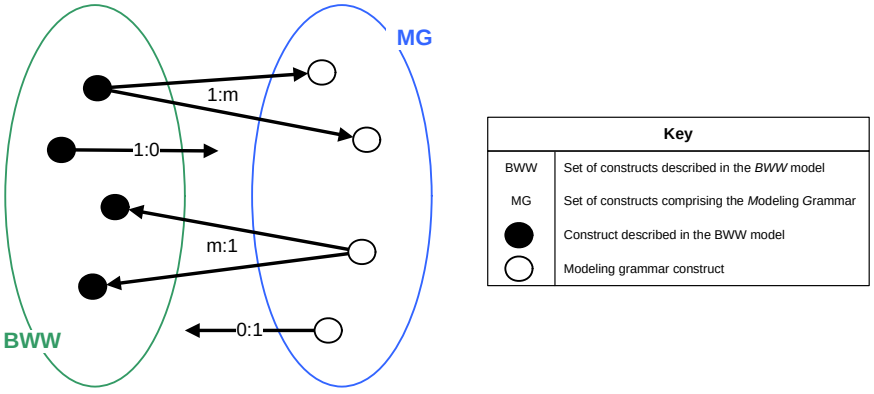

Figure 1. Types of Potential Representational Deficiencies [Weber, 1997]

Representational analysis follows an established methodology [Rosemann *et al.*, 2006a] that specifies three procedural steps necessary to obtain valid and reliable mapping results and related propositions. First, two researchers separately read the grammar specification and map the grammar constructs against BWW constructs in order to create individual first representation mapping drafts. Second, the researchers meet to discuss and defend their mapping results. Third, the jointly agreed second draft is discussed and refined in several meetings with the entire research team (usually at least four members). By reaching a

consensus over the final mapping result a maximum of possible objectivity and rigor in this type of research can be achieved. The same process is then repeated to derive based on the mapping results propositions regarding the impact of the mapping deficiencies on the use of the grammar.

While the levels of maturity and dissemination are impressive and the resulting findings proven to be of relevance, a review of related studies shows that scholarly work has mostly stayed on the level of representational capabilities of modeling grammars. Either capabilities and/or deficiencies were analytically identified or the hypothesized effects of these deficiencies were empirically explored or tested. There remains a need for representational analyses to transcend beyond the level of 'pure' grammar capabilities. After more than two decades and a large multitude of such studies we believe that, in spite of the track record of demonstrated usefulness, the intense focus of previous and current scholarly work based on representation theory on the capabilities of modeling grammars induces an illusion of research progress in regard of a cumulative tradition. Research progress can not solely be achieved by an abundance of papers more or less replicating the findings of previous representational analyses. In fact, we are concerned that the rich basis of representation theory may get lost in a rather inward looking research stream with a high focus on repeating the same methodology for yet another phenomenon associated with conceptual modeling.

As an example for such studies, Gemino and Wand [2005] investigated the consequences of representational propositions regarding the use of optional versus mandatory properties on the complexity of understanding the resulting model. However, as noted above, in general there is a paucity of research exploring the impact that representational deficiencies of modeling grammars have on further dependent variables (see Figure 2). We specifically address the challenge of studying the consequences that representational capabilities have on the intention of a user to continue to use a modeling grammar. This selected consequential

variable lies within the realm of acceptance, adoption and/or diffusion studies, which are traditional and widespread in IS research. In the following we hence explore related theories and models to gain a better understanding for the concept and antecedents of continuance of usage.

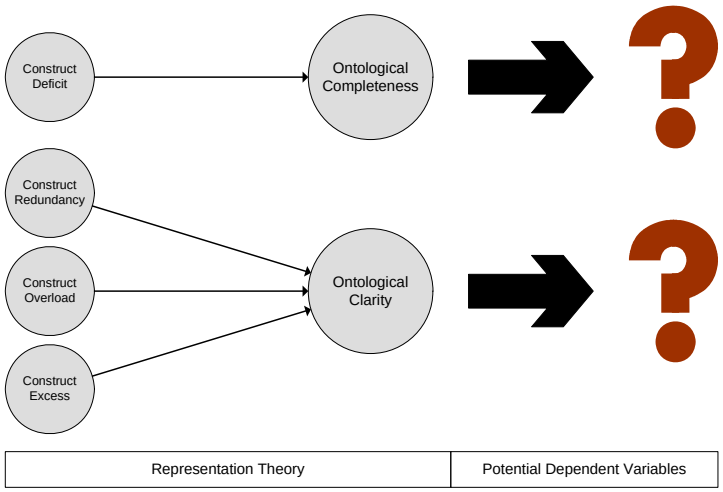

Figure 2. Representation Theory and the Quest for the Dependent Variables

Acceptance of Information Systems

As noted, we seek to study the impact that representational capabilities of modeling grammars have on the continuance decision, which is a surrogate of its overall acceptance. Modeling grammars can be seen as research *artifacts* within the IS discipline [Hevner *et al.*, 2004], and thus we can subsume such a study under the method of studying the acceptance of IS artifacts in general. A wide variety of models exist to explain and measure phenomena associated with the acceptance of IS and/or IT artifacts, including the theory of reasoned action [Ajzen and Fishbein, 1980], innovation diffusion theory [Rogers, 2003], the unified theory of acceptance and use of technology [Venkatesh *et al.*, 2003], the Technology Acceptance Model (TAM) [Davis, 1986, Davis, 1989] and its extension, TAM2 [Venkatesh and Davis, 2000]. Amongst all these, TAM has been identified as the most influential and most commonly employed theoretical framework [Lee *et al.*, 2003]. In fact, the extensive

amount of research related to TAM has reportedly made it one of the most influential and commonly employed IS models overall [Lee *et al.*, 2003]. King and He [King and He, 2006] found in their rigorous meta-analysis of TAM that, despite of its recent adoptions, for example, to the method context [Moody, 2003a], extensions, for example, the TAM2 model [Venkatesh and Davis, 2000], and revisions, for example, the UTAUT model [Venkatesh *et al.*, 2003], primarily the classical model is of high reliability and explanatory power and obtains high levels of robustness. As such, we deem TAM in its original form a suitable starting point for our line of investigation.

The main advantages of TAM are the parsimony and explanatory power of the model [Venkatesh and Davis, 2000] and the well-researched and validated measurement inventory with high levels of reliability and validity of constructs and measurement scales [Davis, 1989, Segars and Grover, 1993].

TAM was initially developed by Davis [1986, 1989] for explaining and predicting voluntary usage of computer systems, assuming that an individual's acceptance of an information system is determined by the two major variables Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) (see right side of Figure 3). Over the past twenty years TAM has been applied to different IS artifacts (for example, email, GSS), under different situations (for example, culture, over time), with different moderating factors (for example, gender, organizational size), and with different subjects (for example, students, knowledge workers, managers). We do not wish to recapitulate each TAM study here and instead refer to the annotated overview given for instance in [Davis, 1986, Lee *et al.*, 2003].

Related studies have found that the constructs of PU and PEOU directly influence an individual's intention to use an IS artifact [Davis, 1989, Davis *et al.*, 1989, Moore and Benbasat, 1991]. Also, PEOU was found to be a causal antecedent of PU [Venkatesh and Davis, 1996, 2000]. However, not all studies found these relationships to be always

statistically significant. In particular, while PU has consistently been found to impact the formation of intention to use, support for PEOU has been inconsistent and sometimes of less significance. An explanation for this is speculated to reside in the fact that prolonged exposure to an IS artifact remedies potential concerns about the ease of its use [Chau, 1996].

Further criticism of TAM focuses on three particular aspects, namely (a) the antecedents and determinants of PEOU and PU, (b) the perceived voluntariness of the usage decision, and (c) the explanatory power of the variance of causal relationships. Regarding the first, Fichman [1992] points out that most studies of IS acceptance/adoption are restricted to applying a general model that does not take into account the specific characteristics of the research context. Hence, while TAM provides the advantage of a rich cumulative tradition, researchers seeking to borrow this theory must take care to ensure that its concepts and variables are being tailored to the specific research context. Along similar lines, it was specifically argued that it is necessary to better understand the determinants of PU [Venkatesh and Davis, 2000] and PEOU [Venkatesh and Davis, 1996] (see Figure 3). We agree with these criticisms that the generality of TAM, which allows for wide applicability, induces a lack of focus on the particular artifact under observation. Hence, as is explained in the next section, we will explicitly explore the determinants of PU and PEOU in the context of contextual modeling grammars by drawing on the principles of representational analysis.

Regarding the second noted criticism, it was Moore and Benbasat [1991] who first recognized that the acceptance behavior of individuals may also be influenced by a mandate from superiors, expressed in a moderating effect of a variable ‘voluntariness’, which in turn has been included in some related studies [Venkatesh and Davis, 2000, Venkatesh *et al.*, 2003]. We acknowledge the importance of voluntariness and include it in our model, as discussed later in this paper. Regarding the third, Lee *et al*. [2003] found that a number of TAM studies resulted in only 25 percent of the causal relationships being explained by the

independent variables. They see a reason for this in the non-consideration of further moderating variables besides the TAM constructs in these studies. We also acknowledge this limitation and later introduce external variables relevant to our study context.

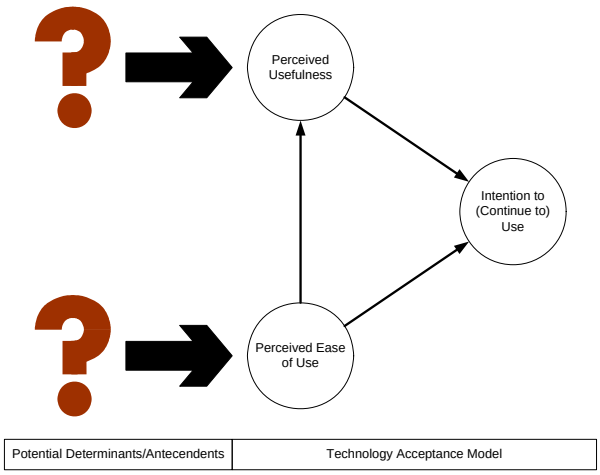

Figure 3. Technology Acceptance Model [Davis, 1989, Davis *et al.*, 1989] and the Quest for its Determinants/Antecedents

A Theoretical Model of the Acceptance of Modeling Grammars

Primary Constructs

In this section we develop a parsimonious model for explaining acceptance of conceptual modeling grammars by modeling individuals, measured by their intention to continue to use a grammar. We will, where applicable, use the example of the BPMN grammar for conceptual process modeling for illustration purposes in order to explain the theory-building process. The starting point for developing this model is TAM in its basic form, which we extend with postulates from representational analysis to explore the determinants of PEOU and PU. Following Figure 2 and Figure 3 we argue that a causal relationship between representational analysis and TAM can be established that can be used to converge these theories.

Starting with PU, Moody [2003a] argues that the original definition of PU [Davis, 1989] must be extended to reflect the objectives of the particular task for which the artifact is being used.

Adopting this insight to the context of conceptual modeling, we can perceive PU as "the degree to which a person believes that a particular grammar will be effective in achieving the intended modeling objective". This definition reflects the notion of rational selection [Rescher, 1973], which states that, generally, those methods will be adopted that outperform others in achieving intended objectives, i.e. those that are more effective. Based on this understanding a link can be theorized to the argument that 'good' grammars are those that contain all the constructs needed to produce *complete* representations of relevant phenomena [Weber, 1997]. Clearly, the notion of a *complete* grammar (without construct deficit) reflects the notion of an *effective* grammar with respect to the objective of conceptual modeling to *build a representation* of selected phenomena in the problem domain [Wand and Weber, 2002]. If users cannot build representations of all phenomena they seek to have represented in their model due to a deficit of desired representation constructs in the used modeling grammars, they are likely to not find the grammar useful. Accordingly, we argue that *ontological completeness* is a determinant of PU of a conceptual modeling grammar (see Figure 4), based on the argument that PU represents a perceptual judgment of an artifact's effectiveness [Rescher, 1973].

PEOU, adopting its original definition [Davis, 1989] to the context of conceptual modeling, can be understood as "the degree to which a person believes that using a particular grammar would be free of effort". Modeling "free of effort" means modeling without complexity [Gemino and Wand, 2005], which in turn provides another link to representational analysis. Weber [1997] argues that, in addition to the question "what" can be represented, also the question "how" it can be represented is of importance. He argues that the clarity of a grammar describes how unambiguously the meaning of its constructs is specified and thus, how much effort is needed to apply desired real-world meaning to them. The notion of clarity embraces the three situations of construct overload, redundancy and excess, i.e., a formative

relationship exists between these sub-constructs and ontological clarity. The underlying argumentation here is that while a certain grammar may be complete in that it provides all constructs necessary to build representations of all desired real-world phenomena, it may offer a wide range of constructs for doing so. Some of these constructs may be redundant in the real-world meaning that users can apply to them, or excessive in that they do not provide any necessary real-world meaning, or even indeterminate in that they carry multiple meanings. Overall, the use of the grammar may cause confusion and/or ambiguity, which potentially obstructs users from readily understanding the models. Again, one can observe a link between the notion of clarity of a grammar and PEOU of a grammar with respect to the aim of conceptual modeling to *facilitate communication and understanding* among stakeholders [Wand and Weber, 2002]. We argue accordingly that *ontological clarity* is a determinant of PEOU of a grammar (see Figure 4).

Sub-constructs

Aside from these primary constructs of the research model, it is necessary to identify the sub-constructs that may form the basis for developing measurement inventories. Such sub-constructs need to be (re-) specified in accordance with the given context [Segars and Grover, 1993]. Consequently, we seek to determine sub-constructs for our primary constructs ontological completeness and ontological clarity (including its three formative constructs) in order to then be able to derive appropriate measurements. Again, we argue that the principles of representational analysis allow us to derive these sub-constructs and the related measurements.

Representational analysis follows a procedure for exploring the four abovementioned representational deficiencies within a grammar (see Figure 1). The identified situations of representational deficiency are argued by Weber [1997] and shown in a number of studies,

for example [Davies *et al.*, 2004, Green and Rosemann, 2002, Recker *et al.*, 2006a], to induce issues for modeling stakeholders working with these grammars, and thus reflect the notions of ontological completeness and clarity.

Regarding ontological completeness, we argue that each identified situation of construct deficit within the grammar under observation can be used as a sub-construct for ontological completeness. For instance, Recker *et al*. [2006a] found construct deficit in BPMN related to concepts of 'states assumed by things', which in turn resulted in a decreased perceived capacity of the grammar for depicting business rules in process models. Hence, the instances of construct deficit found in a modeling grammar impose limitations on the capacity to model certain phenomena in the real-world (such as, for instance, business rules), and thus measure the perceived criticality of ontological completeness, which negatively affects, and thus determines, PU of the grammar.

The situations of construct overload, redundancy, and excess of a grammar do not restrict the capacity of a grammar to model certain phenomena of real-world domains as they do not affect *what* can be modeled. They pose limitations on the way a grammar is being used for modeling as they affect *how* phenomena can be modeled. The same study as above found that real-world things can be represented using BPMN, but only at the extent of construct redundancy, as it was found that two BPMN constructs share the same representational capacity. This in turn was shown to cause user confusion when trying to build and respectively interpret the model [Recker *et al.*, 2006a]. We argue that each identified situation of construct overload, redundancy, or excess in a grammar affects the *effort* that is needed to produce or interpret a model, *viz.*, they can be used to measure the clarity of a grammar, which negatively impacts PEOU of the grammar.

In summation, the method of representational analysis, by means of which it is possible to derive propositions regarding the use of a certain modeling grammar for certain modeling

tasks, gives access to sub-constructs of ontological completeness and ontological clarity that are specific to the respective context, *viz.*, to the grammar under observation. In the case of BPMN, for instance, previous research has identified, stemming from representational deficiencies, a total of nine propositions regarding the use of the grammar for process modeling [Recker *et al.*, 2006a]. We argue that these propositions can be used as a basis from which measurement items can be derived for related empirical studies. In this context, it must be noted that measurement must focus on secondary attributes, i.e., perceptions towards the premises of representation theories, and not the primary attributes of conceptual modeling grammars (i.e., their analytically established extents of completeness and/or clarity). This decision follows the arguments provided by Downs Jr. and Mohr [1976] who concede that secondary qualities of an artifact, i.e., an individual's perceptions of its primary qualities, determine the formation of an attitude towards it. In fact, it is most often not the actual qualities of an artifact that will influence an attitude towards it, but rather the perception of the qualities by the user [Moore and Benbasat, 1991]. In our case, the relevance of perceptions towards representation fidelity holds even more so. A representational analysis can only suggest deficiencies or capabilities in terms of clarity or expressiveness. However, a theoretically established representational (dis-) advantage does not necessary imply a practical or observable (dis-) advantage [Gemino and Wand, 2005]. In fact, it must be exploited whether users of conceptual modeling grammars perceive theorized primary qualities and/or deficiencies as such.

As an example, our research model of grammar acceptance in Figure 4 uses the case of BPMN and includes the accordant sub-constructs in the context of the BPMN grammar, derived from the previously accomplished representational analysis of BPMN.

Moderating Constructs

In every scientific study it is necessary to identify and take into account endogenous variables that potentially impose a strong contingency effect on the 'independent variable-dependent variable' relationship. Moderating variables must be identified based on the respective context [Fichman, 1992]. We draw on variables that have previously been identified, and validated, to pose consequences to our particular research context. Previous representational analyses of process modeling grammars identified and explored four distinct contextual factors that moderate the level of the perceived criticality of the identified representational deficiencies, and which we accordingly include in our model (see Figure 4):

- Green *et al*. [2002] identified the *modeling role* (for example, business analyst, technical analyst), that the modeling subject occupies in the referred modeling initiative, as a moderating variable. Recker *et al*. [2006a] found further support for this statement.
- M*odeling purpose* was hypothesized by Rosemann *et al*. [2000] to also moderate the perceived criticality of representational deficiencies. Davies *et al*. [2004] found evidence for this proposition. In the area of process modeling, for instance, workflow engineering has the requirements of sound and precise process models without deadlocks or starvation areas [Kiepuszewski *et al.,* 2003]. These requirements are, however, of less relevance to business requirements documentation purposes, which have a different set of representation needs that a model has to meet.
- M*odeling experience* was found by Davies *et al*. [2004] to further explain some of the variances between responses for each of the representational deficiencies explored. Less experienced modelers often have not yet encountered modeling scenarios in which certain representational deficiencies would induce problems in the use of the language. For instance, if a modeler has not yet used a certain potentially ambiguous language construct

he/she would not know how critically a related grammar deficiency would impact his/her modeling.

- Recker *et al*. [2006a] found that aside from these three contextual factors also the *modeling tool*, in which the modeling grammar is implemented, moderates the perceived criticality of representational deficiencies as some of the deficiencies can be overcome by means of tool functionality (for example, model repository, meta-tags and additional attribute fields, for instance).
- In line with the findings of Davies *et al*. [2004], the study by Recker *et al*. [2006a] further found that in modeling practice, language users often do not use the modeling grammar in its original version. Instead of using a 'vanilla' specification, organizations often follow a set of modeling conventions that restricts the set of language constructs to be used and sometimes even applies new meanings to particular constructs. Consequently, in cross-organizational studies consideration has to be paid to the factor that existing modeling conventions may restrict or alter the original specification of a grammar, which in turn may have an impact on its representational capabilities and the way that language users perceive potential deficiencies.

Aside from these four modeling context-specific constructs we draw on one of the identified limitations of previous TAM studies, namely the impact of 'voluntariness'. Indeed, in most cases, the usage of a particular modeling grammar is mandated in organizations by superiors such as modeling coaches, consultants or other influential individuals. Accordingly, we argue that the extent of voluntariness impacts the causal relationship between the intention to use a modeling grammar and the actual usage of the grammar.

Figure 4 gives our instantiation of the grammar acceptance model. It includes, for illustration purposes, the sub-constructs specific to the BPMN grammar for the independent variables

(ontological completeness and ontological clarity) that have been identified by means of a representational analysis of BPMN.

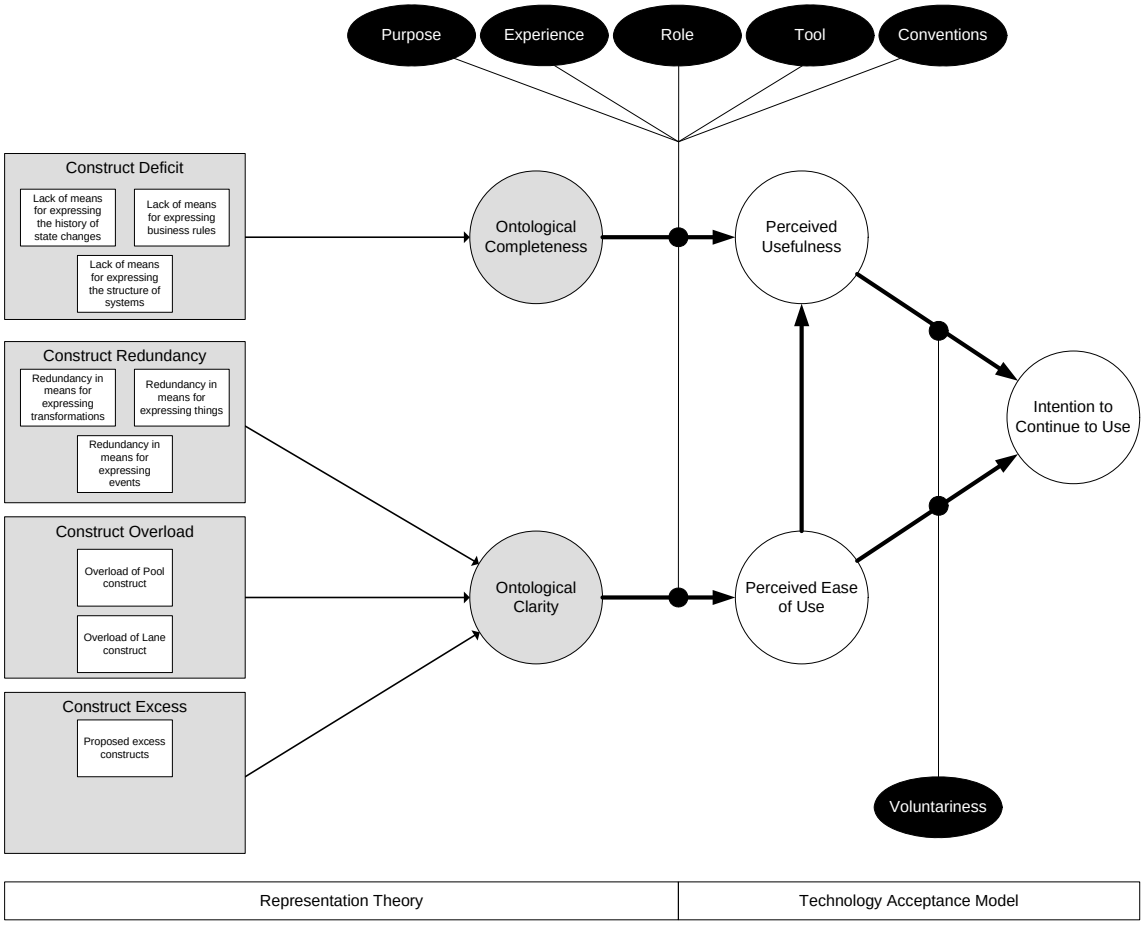

Figure 4. Grammar Acceptance Model, applied to the BPMN grammar

Contributions & Outlook

This paper reported on the development of a theoretical model explaining and predicting user acceptance of modeling grammars, using as an example the BPMN grammar. Our model builds on, and converges, concepts of TAM and representational analysis and proposes a causal relationship between the latter and the former.

So far we have discussed the theoretical foundations of our model. Yet, while referral to established theories can provide guidance to identifying candidate constructs potentially relevant to the particular context, the resulting model can only be *a-priori* given the absence

of empirical studies. In particular, due to space limitations, we have not discussed the development of measurement items in this paper. An overview of the measurement development procedure, which followed the design of Moore and Benbasat [1991] and the resulting scales can be obtained from the contact author upon request.

Our forthcoming research will be as follows.

We will convert the developed measurement instrument to a web-based survey. The selection of the survey research method over other methods, such as experiments (which are quite popular in conceptual modeling research) stems from the observation that surveys allow for generalization of study results to larger populations and also for rigorous statistical testing of theorized constructs over different groups, places and times [Newsted *et al.*, 1996]. Specifically, surveys are well-suited to predict behavior [Malhotra and Grover, 1998], which is the focus of our investigation. Also, there is no need for control over behavioral variables, which would have motivated an experimental design.

We will distribute the survey amongst actual users of BPMN. In order to account for the fact that user perceptions and intentions may change over time [Lee *et al.*, 2003] we will conduct a longitudinal study measuring these quantities at two points in time, (a) in a period of early adoption and exposure to BPMN, and (b) in a later period of increased familiarity with the grammar. This allows us not only to counteract the criticism of most TAM studies being restricted to cross-sectional studies [Agarwal and Karahanna, 2000], but also to account for, and further explore, the moderating effect of modeling experience on representational deficiencies and their impact on the formation of the continuance decision. Finally, a web-based format of the instrument allows us to gather data from a multitude of potential respondents across different regions and cultures, thereby overcoming the bias of restricted contextual settings and supporting potential cross-contextual analyses.

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